

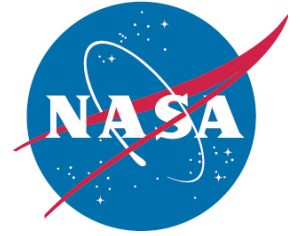
Suborbital Telepresence and Over-the-Horizon Networking

Lawrence C. Freudinger – NASA/Dryden Flight Research Center



Motivation

- **Decision Support**
 - Situational Awareness *with enough time to do something about it*
- **Test & Measurement Activities**
 - Airborne instruments
 - Earth science, space exploration and aeronautics applications
- **Network-centric thinking**
 - Network-distributed operations
 - Network computing: sensor webs
 - Toward easy, affordable, useful networking to/from aircraft



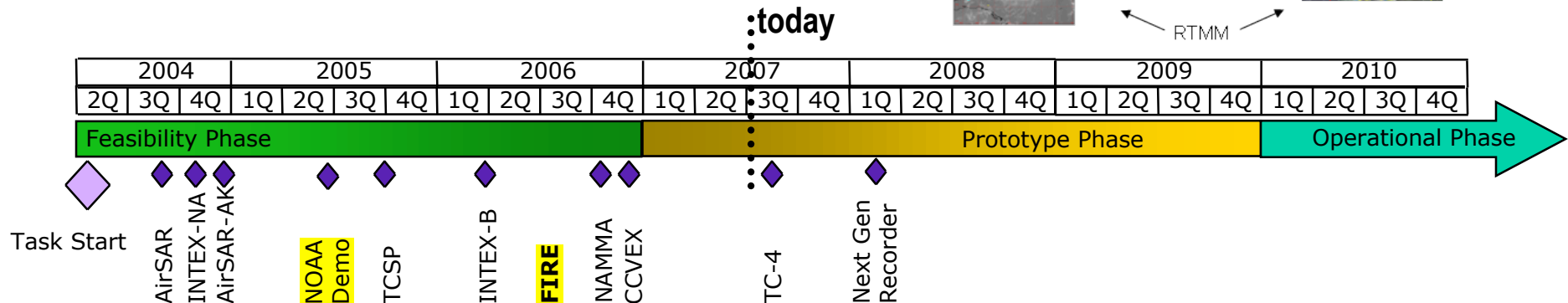
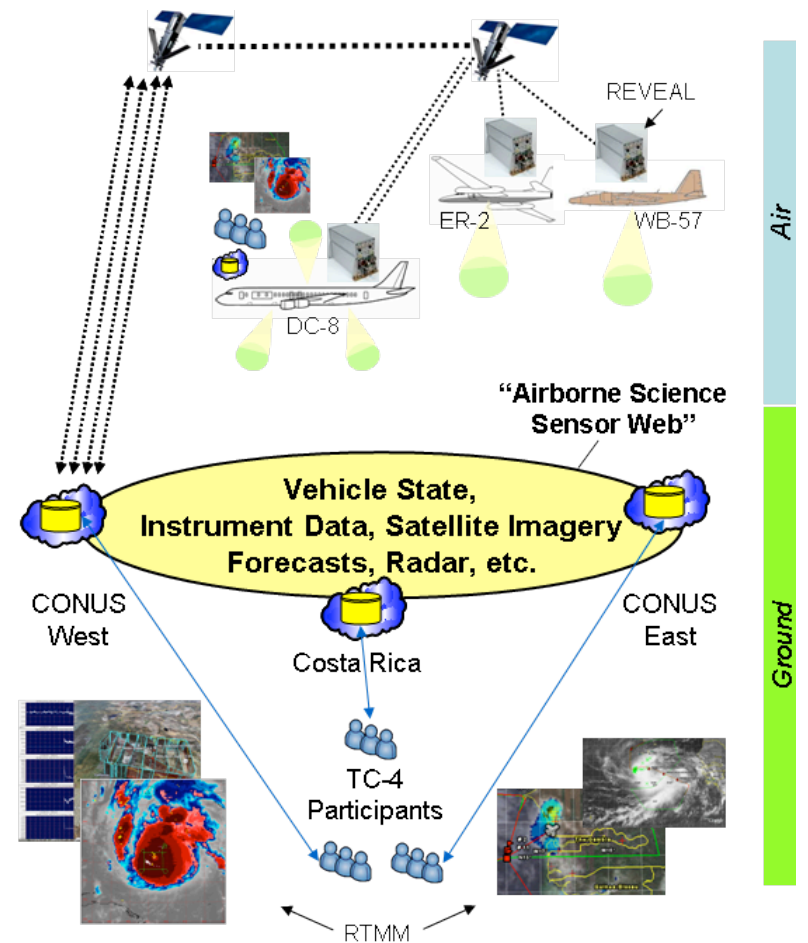
Outline

- **Where We Are**
 - Earth Science Capabilities Demonstrations, Suborbital Telepresence Project
 - Recent accomplishments
- **Next Steps**
 - Upcoming Mission
 - Disruption-Tolerant Networking

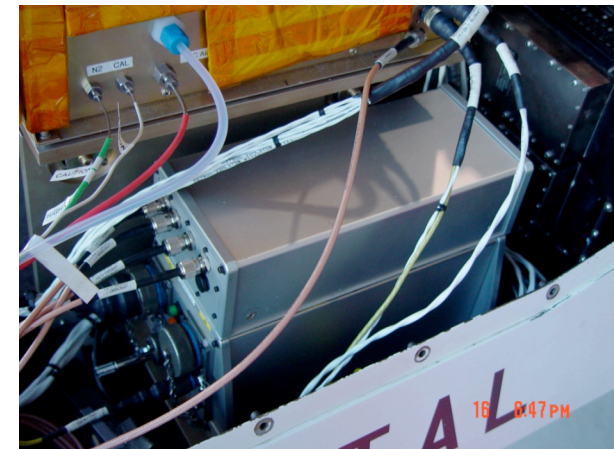
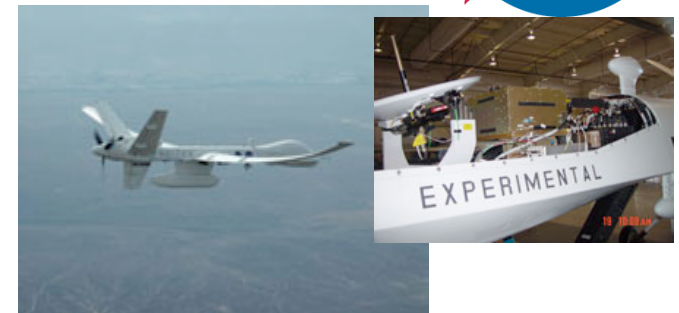
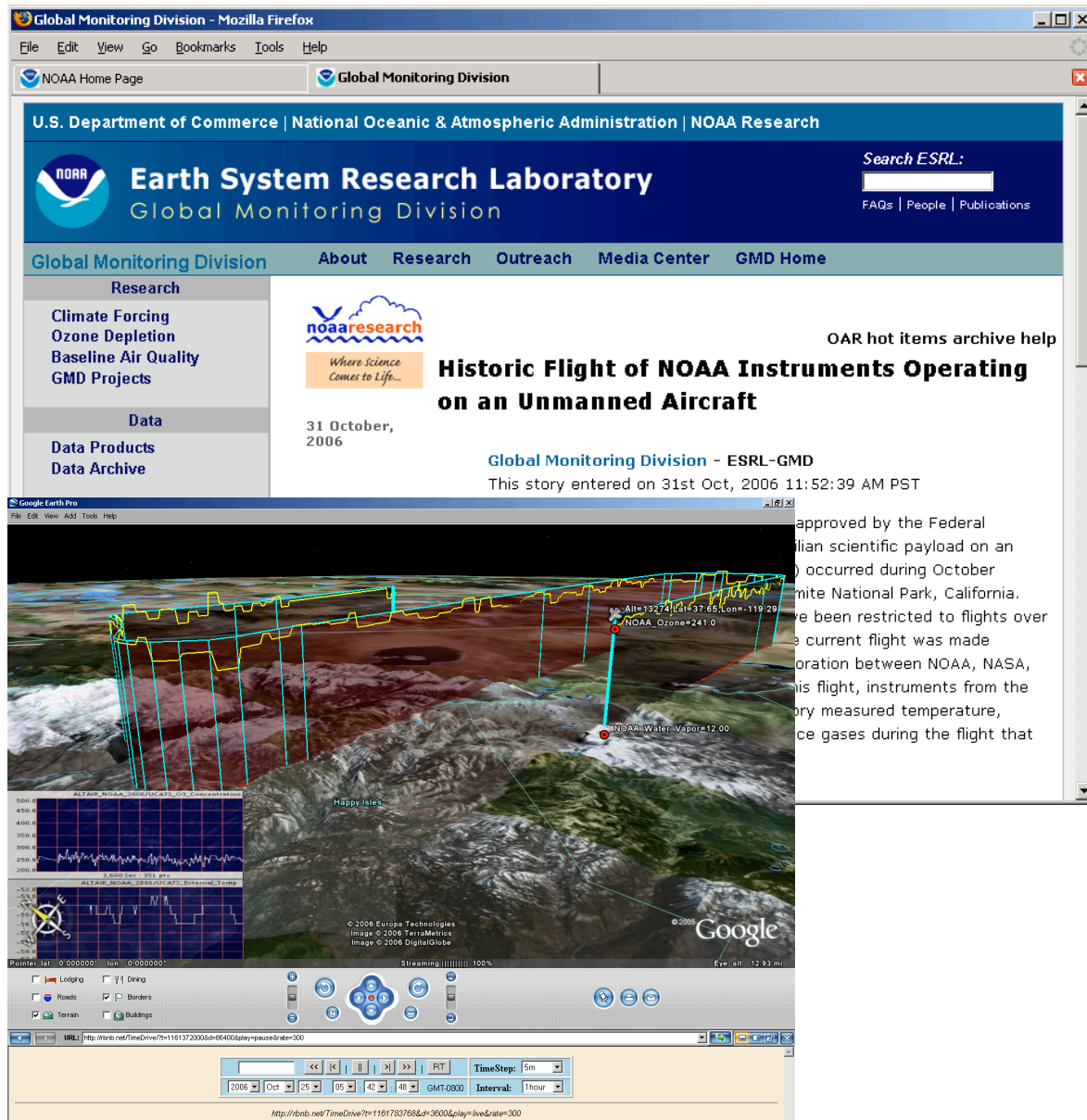
Suborbital Telepresence and Global Test Range

Objectives

- **Develop/demonstrate low-cost products and services for airborne science**
 - Sensor web: *i.e.* Instrument interaction/C4I
 - Situational awareness, decision support
 - Global-Reach Realtime Mission Monitoring
- **Necessary on future autonomous vehicles, but value in application to *all* platforms**
- **Onboard system focus: payload needs**
 - Acquisition, integration, recording, processing, communications mgmt services
- **Terrestrial system focus: operation needs**
 - Data processing, fusion, distribution, display, playback services

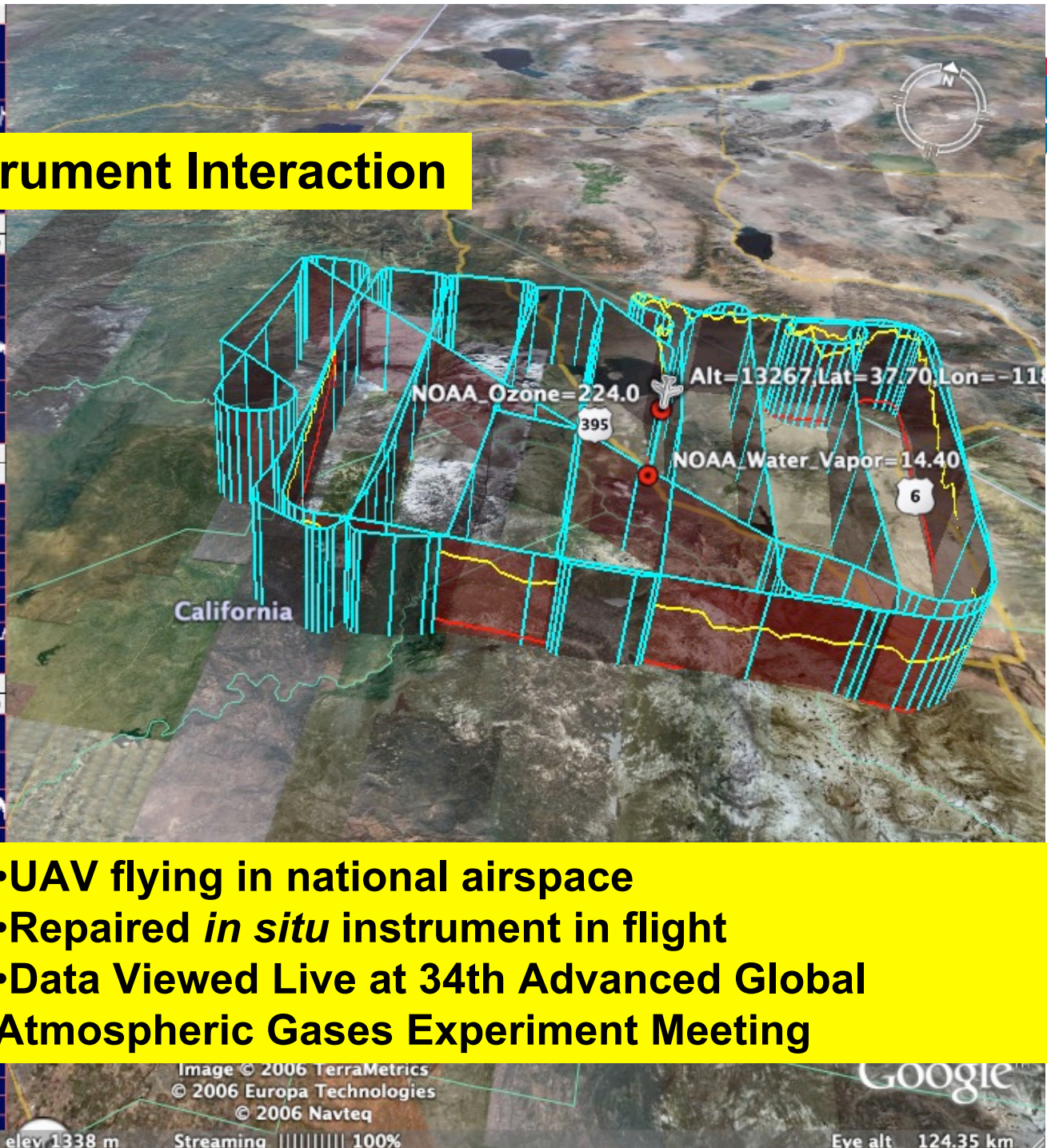
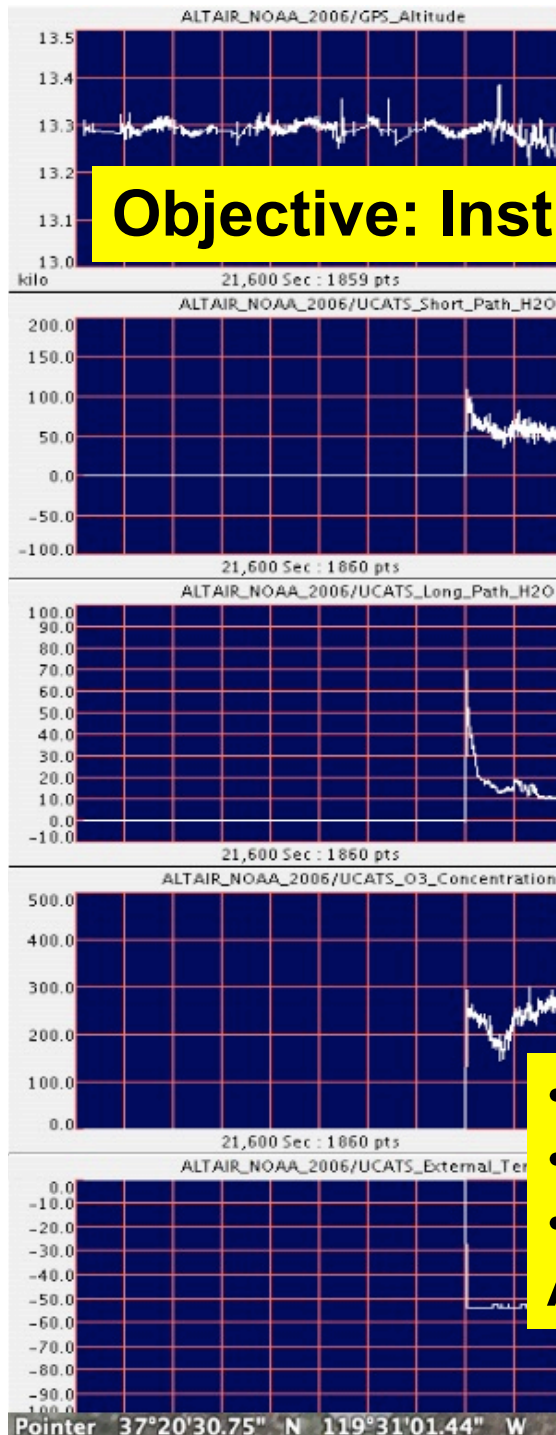


Objective: Demonstrate Capabilities

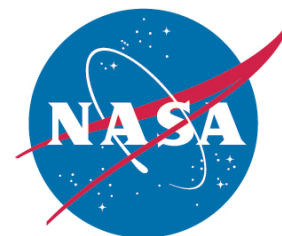


Fire Mission October 2006

Objective: Instrument Interaction



- UAV flying in national airspace
- Repaired *in situ* instrument in flight
- Data Viewed Live at 34th Advanced Global Atmospheric Gases Experiment Meeting

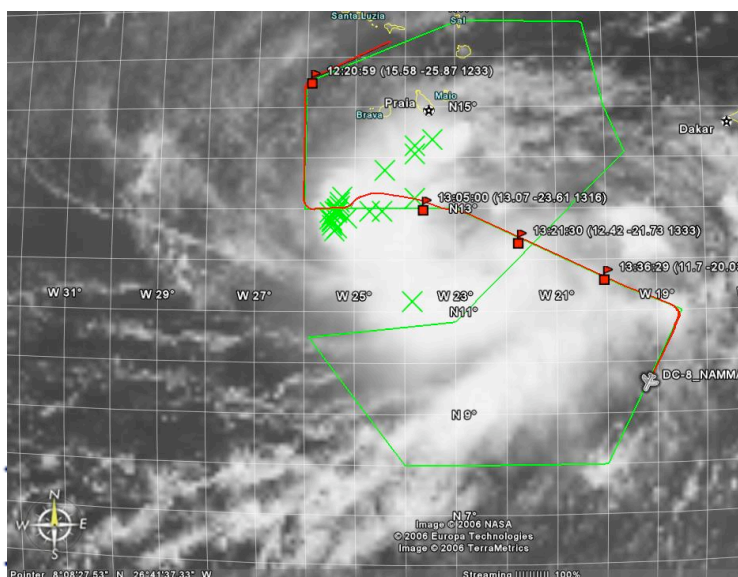


Objectives: Demonstrate Capabilities

Aug/Sep 2006: NASA African Monsoon Multidisciplinary Analysis

“Major step forward in our capabilities for doing real-time monitoring and direction of missions” – Dr. Ed Zipser

- Tropical meteorology students participated from Utah (8 Sep 06)



NASA - Airborne Science in the Classroom: The Next-Best Thing to Being There - Mozilla Firefox

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FEATURES

Airborne Science in the Classroom: The Next-Best Thing to Being There 03.05.07

It was early in the fall semester, and to University of Utah meteorologist Ed Zipser, it was the perfect day to be teaching a graduate course in tropical meteorology.

Image right: Used for the NAMMA mission, NASA's DC-8 Airborne Science research aircraft takes off. NASA photo by Tony Landis

Zipser had just returned from the NASA African Monsoon Multidisciplinary Analysis - or NAMMA - field campaign based in the Cape Verde Islands, off the west coast of Africa. Zipser was chief scientist for the NAMMA mission.

NASA's DC-8 Airborne Laboratory was still conducting NAMMA research missions, probing an easterly atmospheric wave off the African continent. These easterly waves are storm systems that occasionally develop into tropical cyclones, and the main purpose of NAMMA was to find out the differences between the developing and non-developing waves.

Image left: The flight path of NASA's DC-8 during a NAMMA mission off the west coast of Africa is overlaid on this satellite photo from Google Earth.

Armed with a notebook computer and an Internet connection, Zipser effortlessly immersed students in the research activity. Through live displays of the DC-8's position fused with weather imagery and other meteorological essentials, students were able to view exactly what was unfolding five or six time zones away. They saw the same displays of satellite images and locations of lightning strikes that researchers aboard the DC-8 and in the operations center on the Cape Verdes were seeing. Even better, they were able to interact with



Tropical Composition, Cloud, and Climate Coupling Experiment (TC⁴)

- Costa Rica Operations Jul-Aug, 2007
- Team distributed across Western hemisphere
- Study chemical, physical, dynamic processes in upper troposphere and transition layer between troposphere and stratosphere.
- 3 aircraft in coordinated flights
 - Over and through storms
 - Under A-Train Satellites
- >60 in situ and remote observation instruments
 - Add radar and balloon observations
 - Add predicted observations (forecasts)



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

- + NASA Portal
- + NASA Ames
- + NASA Earth Science Division

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Earth Science Project Office

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TC⁴

Tropical Composition, Cloud, and Climate Coupling

Costa Rica 2007

Many facets of the chemical, dynamic, and physical processes occurring in the tropical upper troposphere and tropopause transitional layer are not well understood. Identifying the key processes in this region is essential for progress on issues involving global climate change, stratospheric ozone depletion, and global tropospheric chemistry.

The NASA TC4 (Tropical Composition, Cloud and Climate Coupling) mission will investigate the structure, properties and processes in the tropical Eastern Pacific. A-train satellite observations provide crucial information on the spatial and temporal variations of this region, however, carefully planned TC-4 aircraft observations are required, both to validate satellite data and to provide critical observations not available from the satellites. High altitude aircraft will collect tropopause data while the medium altitude aircraft will provide profiles and structure measurements of the tropical upper troposphere and lower stratosphere.

TC4 is sponsored by the NASA Headquarters Atmospheric Composition Focus Area including the Upper Atmospheric Research Program (Michael Kurlyo, Program Manager), the Radiation Science Program (Hal Maring, Program Manager) and the Tropospheric Chemistry Program (Jim Crawford, Program Manager). TC4 is planned for July 2007 in San Jose, Costa Rica.

ESPO News:

TC4 Mission to include the NASA DC-8, ER-2 and the WB-57 aircraft. Planning is currently underway.

Freedom of Information Act

The President's Management Agenda

NASA Privacy Statement, Disclaimer, and Accessibility Certification

NASA Official: Mike Craig

Project Manager: Marilyn Vasquez

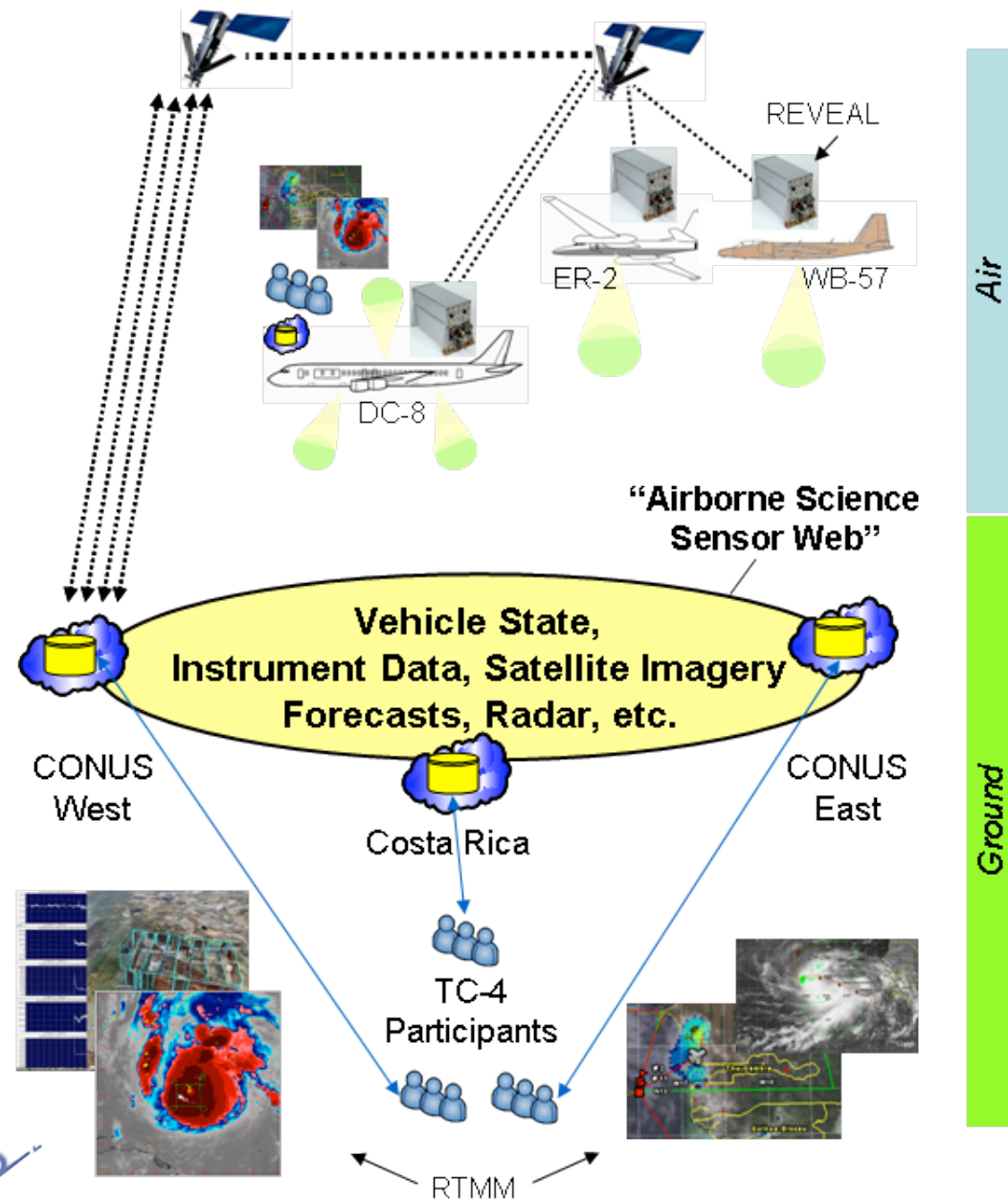
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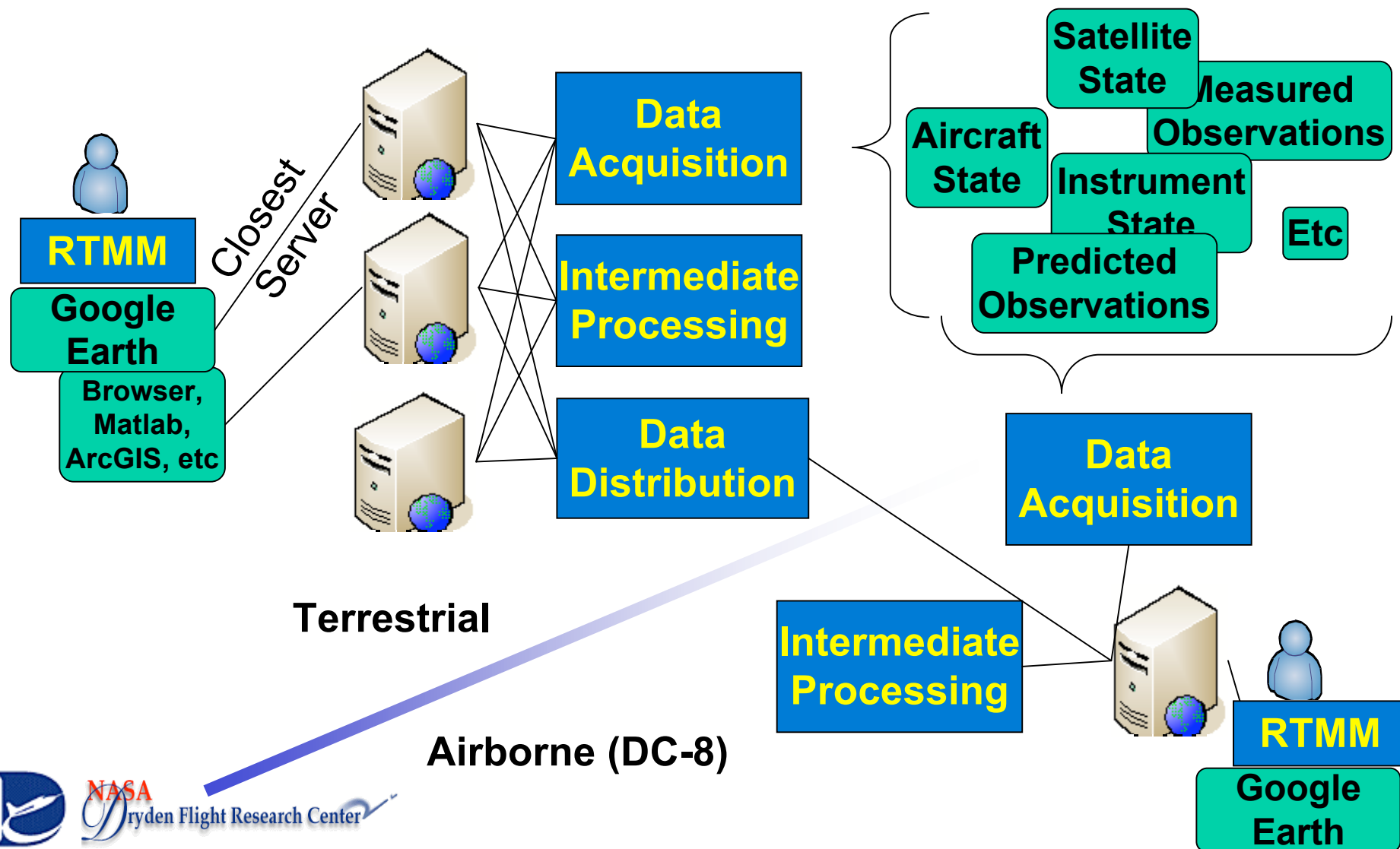
Data Sets for TC⁴ Real-time Monitoring

- **Satellite Imagery**
 - GOES-E, GOES-10 (vis, infrared, ~15 min update)
 - Satellite & instrument FOVs – current and predicted tracks
 - Satellite products (e.g., to support postflight activities)
- **Model Output**
 - GEOS-5 & WRF model outputs available
- **Aircraft Instruments**
 - Flight tracks (waypoint and real time tracks)
 - Dropsonde (time/locations and skew-T)
 - Aircraft Instruments: health/status, data, cmd/cntrl (case-by-case) (LASE, Dial, AMPR, MTS, SSFR, PT, CAPS...)
- **Surface and Balloon Observations**
 - Radar (NPOL, SMART)
 - Lightning (Vaisala long range, Costa Rica lightning, WWLLN)
 - TicoSonde
 - Other (NATIVE)
- **Stop-action playback for review and analyses**





TC-4 Notional Architecture

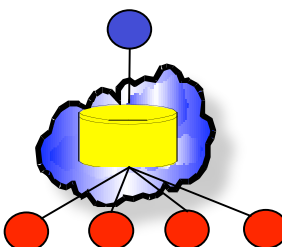




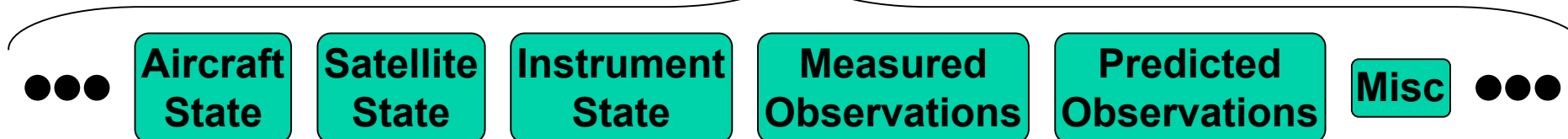
An Application Integration View



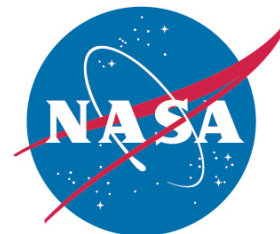
Your application(s)



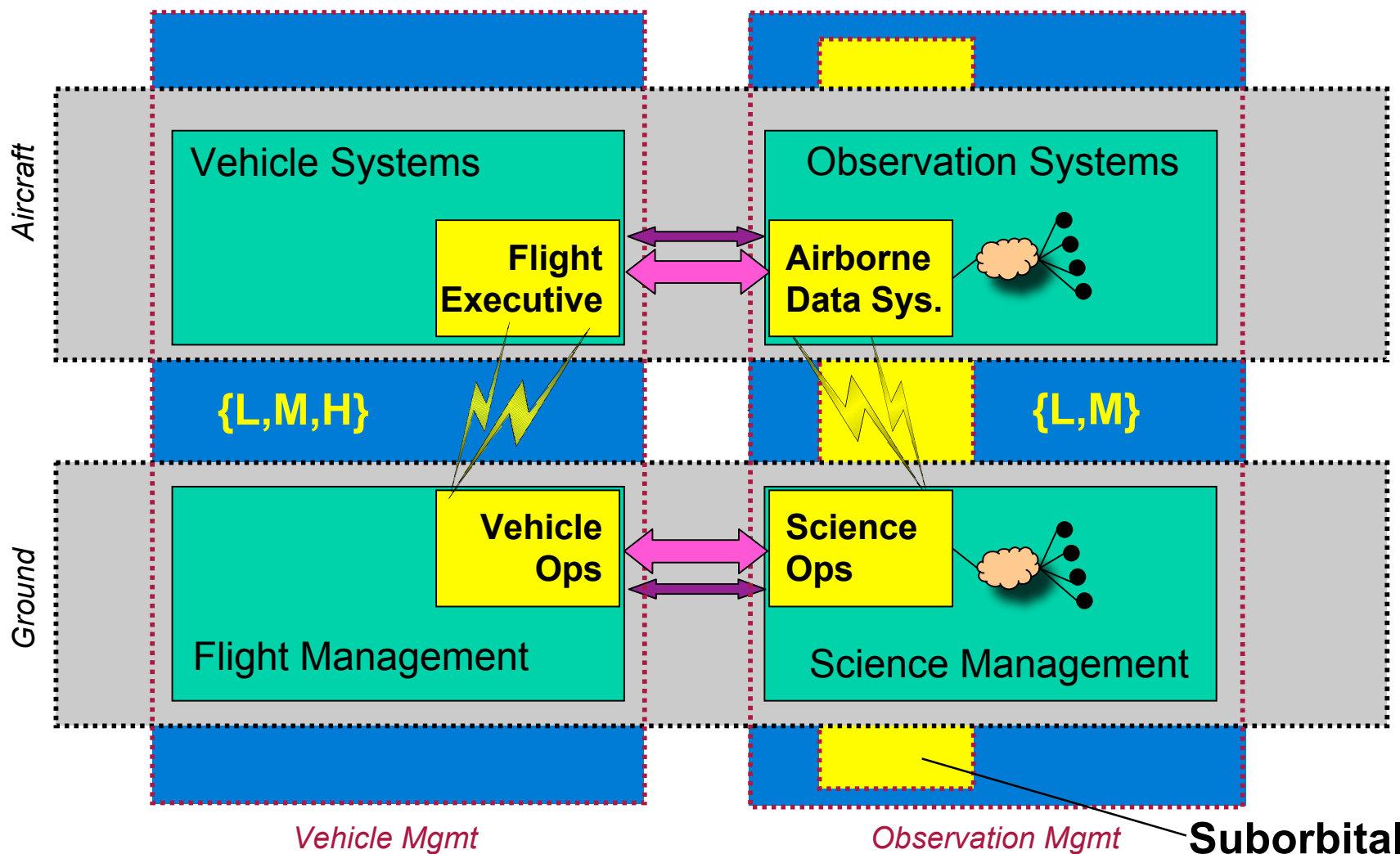
“the network”



All necessary data sources
Heterogeneous distributed sources



Telepresence: Architectural Framework





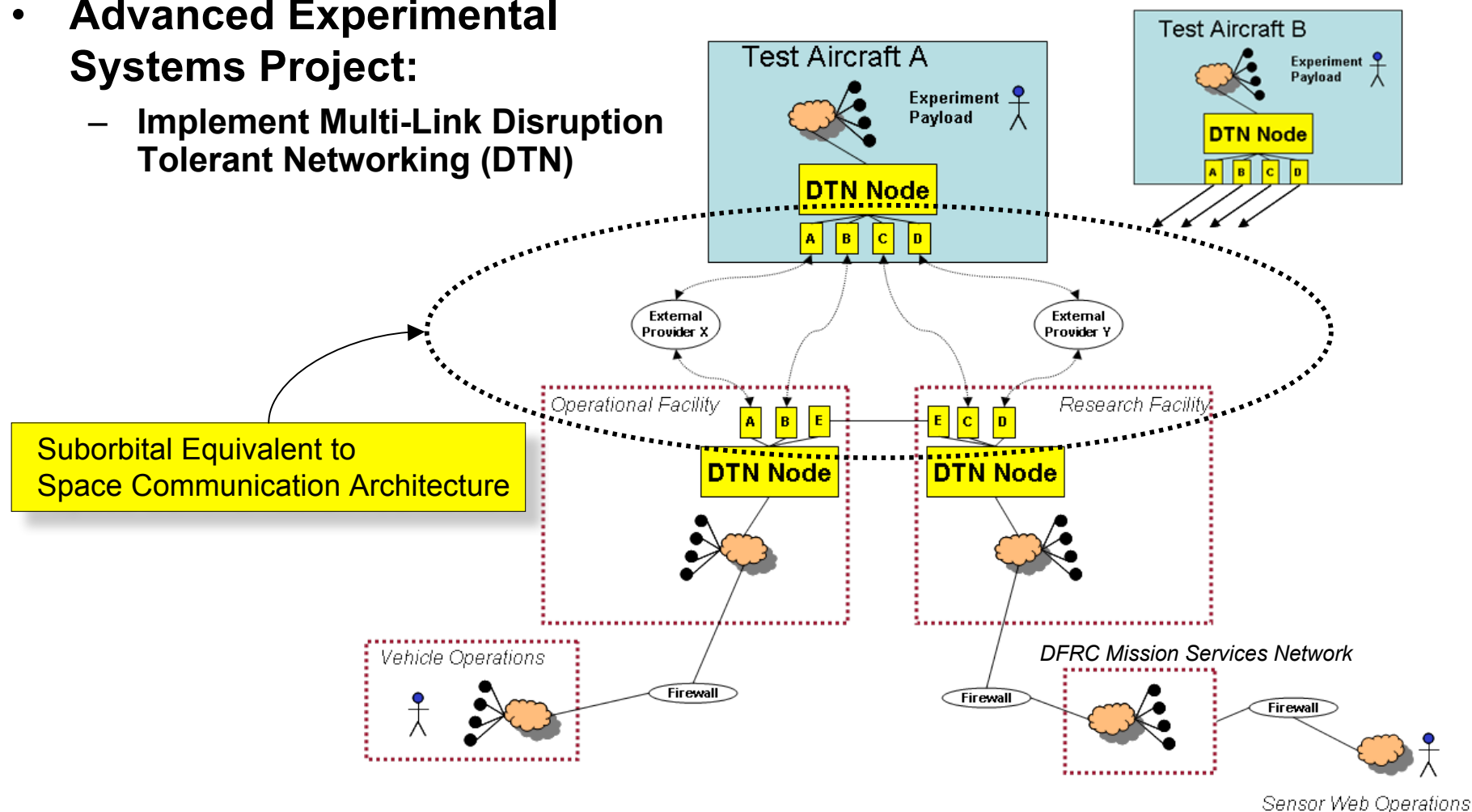
Where to next?

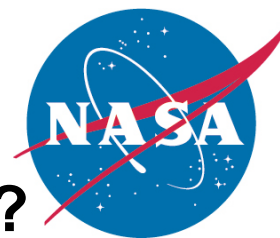
- **Disruption Tolerant Networking (DTN) with aircraft**
 - **Classic Internet protocols (TCP-IP) designed for**
 - “low bit error rate” environments
 - “low latency” environments
 - Symmetric link characteristics
 - End-to-end connectivity in quasi-static topologies
 - **But Internet finally catching up with aerospace and test/measurement needs**
 - Space Communications Protocol Standards (SCPS) Evolving for 15 years
 - Disruption Tolerant Networking R&D efforts expanding rapidly
 - IRTF: DTNRG.ORG
 - Significant DARPA DTN investment
 - Bundle Protocol (BP) Draft Specification v6 available Apr07
 - DTN BP is a store-and-forward overlay network
 - addresses general problem of managing end-to-end management of network transfer where end-to-end connectivity may not exist.
 - Scheduled, opportunistic, and predicted connectivity in dynamic topologies
 - **DTN enables the vehicle payload to be its own autonomous Internet that cooperates with other vehicles and other ground networks as necessary**
 - Long term: The network is a distributed autonomous intelligent system of systems
 - Near Term: better performance, more flexibility, extended line of sight, etc.



Disruption Tolerant Networks

- **Advanced Experimental Systems Project:**
 - Implement Multi-Link Disruption Tolerant Networking (DTN)





Concluding Thought: Why Network Computing?

“...to enable men and computers to *cooperate* in making decisions and controlling complex situations without inflexible dependence on predetermined programs”

- J. C. R. Licklider, 1960

IRE Transactions on Human Factors in Electronics,
volume HFE-1, pages 4–11, March 1960. <http://memex.org/licklider.pdf>



*The lack of situational awareness causes lost opportunity.
Decision-support webs are the reason the Internet exists!!!*